Biogeochemical study of aquatic ecosystems of India

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By

Rupa Mukherjee

Under the supervision of

Dr. Sanjeev Kumar

Associate Professor
Geosciences Division

Physical Research Laboratory, Ahmedabad, India

DEPARTMENT OF CHEMISTRY

MOHANLAL SUKHADIA UNIVERSITY

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DECLARATION

I, Ms. Rupa Mukherjee, D/O Lt. Shanti Pada Mukherjee and Smt. Laxmi Mukherjee, permanent resident of Manbazar, Purulia, West Bengal-723131, hereby declare that the research work incorporated in the present thesis entitled “**Biogeochemical study of aquatic ecosystems of India**” is my own work and is original. This work (in part or in full) has not been submitted to any University for the award of a Degree or a Diploma. I have properly acknowledged the material collected from the secondary sources wherever required and I have run my entire thesis on the Anti-plagiarism software namely ‘**iThenticate**’. I solely own the responsibility for the originality of the entire content.

Date:

Rupa Mukherjee

(Author)

Dedicated to my
Parents and Brothers

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Abstract

Coastal lagoons and estuarine ecosystems regularly undergo natural and anthropogenic forcings that make these ecosystems susceptible to eutrophication, particularly due to increased nutrient loading from anthropogenic activities. This causes these ecosystems to sustain high biological production leading to several cascading effects such as hypoxia and shift in community composition. At present, our knowledge of nitrogen and carbon cycling in such aquatic ecosystems of India, particularly with respect to rates of different biogeochemical processes, remains rudimentary. The present work aimed to study different aspects of nitrogen and carbon cycling in two such systems of India located at the interface of land and sea i.e., the Chilika lagoon and Hooghly-Sundarbans estuarine system. The study attempted to measure the rates of dissolved inorganic nitrogen and carbon uptake rates in the above-mentioned systems. Stable isotopic composition of nitrogen and carbon were also measured in organic and inorganic phases to understand the sources of organic matter and dissolved inorganic carbon dynamics, respectively. Based on the data gathered during the present study and that available in literature, a preliminary model for nitrogen budget was also constructed for the Chilika lagoon.

Overall, the results showed high dissolved inorganic nitrogen (nitrate and ammonium) uptake rates in the Chilika lagoon compared many other aquatic ecosystems with relatively higher preference for ammonium than nitrate. On an average, the turnover time for ammonium in the water column of the Chilika was shorter compared to nitrate suggesting faster cycling of ammonium in the lagoon. Interestingly, the nitrate and ammonium uptake rates in the bottom waters of the lagoon were comparable to the rates observed in the surface waters, pointing towards the importance of benthic biogeochemistry in shallow aquatic ecosystems like Chilika. The calculation of sector-wise uptake rates indicated the highest dissolved inorganic nitrogen fixation in the central sector of the lagoon. A preliminary investigation based on the present and literature data showed atmospheric deposition to be a major potential source of new nitrogen to the lagoon. Considerable N_2 fixation was observed in the

lagoon indicating diazotrophic activity in the lake despite high nitrate and ammonium concentration in the water column.

The northern sector of the lagoon showed the highest particulate organic carbon and nitrogen compared to other sectors with relatively lower carbon isotopic composition of particulate matter during postmonsoon suggesting dominance of terrestrial and freshwater inputs to the lagoon and/or production of freshwater phytoplankton during that season. Significant increase in carbon isotopic composition from particulate to sediment organic matter in the Chilika indicated biogeochemical transformation of organic matter in the water column and during burial.

The deviation of dissolved inorganic carbon and its carbon isotopic composition from the respective conservative mixing values suggested different processes to be active during different seasons in modulating the dissolved inorganic carbon dynamics in the lagoon with dominance of carbon dioxide outgassing and carbonate dissolution across seasons. The carbon uptake rates in the surface waters of the Chilika were higher during the monsoon and premonsoon compared to postmonsoon with comparable rates in the bottom waters.

In the Hooghly-Sundarbans system, the dissolved inorganic nitrogen (nitrate and ammonium) and carbon uptake rates in the anthropogenically influenced Hooghly estuary were significantly higher than the rates in the mangrove dominated Sundarbans. Similar to the Chilika, the preference for ammonium was higher compared to nitrate in the water column with faster turnover for ammonium within both Hooghly and Sundarbans.

The particulate organic carbon concentration in the Hooghly was marginally lower than the Sundarbans with relatively higher values in the freshwater zone of the Hooghly. On an average, carbon isotopic composition of particulate organic matter in the Hooghly was relatively lower compared to that of the Sundarbans suggesting relatively higher influence of terrestrial inputs in the Hooghly. Signals for marine influence or biogeochemical modification of particulate organic matter were found in the Sundarbans.

Abbreviations

‰	Per mil
$\delta^{13}C$	Isotopic composition of carbon with respect to V-PDB
$\delta^{15}N$	Isotopic composition of nitrogen with respect to Air-N_2
C	Carbon
CIL	Cambridge Isotope Laboratories
Chl*a*	Chlorophyll *a*
DIC	Dissolved Inorganic Carbon
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphate
DON	Dissolved Organic Nitrogen
N	Nitrogen
HABs	Harmful Algal Blooms
IPCC	Intergovernmental Panel on Climate Change
IAEA	International Atomic Energy Agency
IRMS	Isotope Ratio Mass Spectrometer
O_2	Oxygen
P	Phosphorous
POM	Particulate Organic Matter
POC	Particulate Organic Carbon
PON	Particulate Organic Nitrogen
SOM	Sediment Organic Matter
C_{org}	Organic Carbon
DO	Dissolved Oxygen
VPDB	Vienna-Pee-Dee-Belemnite

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